Error Recovery by the Use of Sensory Feedback and Reference Measurements for Robotic Assembly

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Abstract

Industrial robots need instrument or parts transport to do which requires coordinate to show the robot's instrument, parts and body. When investigating the robot location, we are usually interested in measuring its location relative to a reference coordinate system. In this system it is attempted to make the assemble direction smaller by designing the sensor board and making use of an instrument for self-adaptation of the gripper to the gripper working environment pallet. In addition, in order to eliminate the robot errors and parts transport system errors to the robot, there are different models employed using different sensors. In this research, the LASER sensors are used based on their applicability and cost. In present article, the V-REP software is used in order to simulate the mechanism. Considering the simulation results it can be stated that the RCC is an optimal model. Based on explained models in different sections of the article, this model can eliminate many of the errors in assemble by an optimal structure and reliable restriction and considering the geometrical uncertainty; for example, nail and hole, unreliability of friction coefficient etc. in addition, this model helps the fragile plastic parts assemble.

1. Introduction

Making use of robot in industrial countries has long been common in production lines. The main reason for this can be its cost effectiveness, increasing the products quality and production with uniform quality, production promotion, waste minimization, reduction of raw materials used and energy consumption. Quality improvement for employees and their safety and health and as a result reduction of treatment costs and working complexities are among other consequences of making these systems used in production line [1]. But, it is better to know that making use of the robotic arms makes the working place smaller, reduction of capital costs, increasing the efficiency and products flexibility [2]. The robotic arms flexibility is a positive aspect based on their programmability which allows the industries expecting to take any action accurately and rapidly by these systems. So, as product process or model and type are changes, there is no longer requirement for new machineries or major changes in production

lines. The simplest industrial robot model as the most cost effective one can carry load between 90-150 kg and their accessibility radius is about 2-3 m. carrying power means the maximum weight these robots can carry and doesn't mean that in making them used it has to be loaded with the maximum quantity. Usually, it is observed that due to the low price, these models are used for light weighted tasks [3]. Robotic arms' accuracy and speed in assembling is of significant importance. Based on the instrument mounted on the robot, there are various operations from parts placing in each other, fixing the screws or bolts, clinching, soldering electronic boards etc. to placing the spring pins are expected to be performed by industrial robots in assembling operation [1]. One of the challenges faced in manufacturing and assembling is the sensitive parts pairing irregularly which need high accuracy about 0.01 mm in which the sensors can be used and the robot movement errors, parts displacement and assembly issues can be overcome [4]. Generally, the assembling

technology requires employing the durable working and human capabilities rather than machines. Performance of an automatic assembling system depends on the working parts geometry. Even slight changes in product cause substantial changes in systems. In addition, automatic systems require a fully controlled working environment. This means that locations and directions of the parts and system sections have to be identified precisely. Using the sensors and machine vision, the automatic instruments and robots can automatically scan the working place and make the changes identified and adapt their behavior in term of the real locations [5]. Accordingly, the main objective of this research is to improve the probable errors when assembling the parts in which it is attempted to reduce the errors to minimum percentage for the final effectiveness using the sensors and limited working environment.

2. Automatic assembling system

Automation target of the production supporting systems is to reduce the manual and official activities in product designing, programming and production control and commercial tasks of the plant. Recently, all modern production supporting systems are complemented using the computer systems. In fact, computer technology is used well in order to make the production systems automation complemented in factories. The term "computer reference production" refers to making broad use of computer systems for product designing, programming the manufacturing, operation control and different commercial actions required in the factories [6]. Automatic production systems in factories are employed for physical products. They conduct operations such as processing, assembling, and inspection and material transportation and in some cases; they take more than one action in the same system. They are called automatic because their operation is performed with least human intervention in comparison with manual processes. In some fully automatic system there is no place for human interventions [7]. At present, in robotic assembling cells there are shortcomings with robots in small productions. At first, robots cannot be effective in actions conducted in complex environment with environmental information support. They often rely on external sensors to help the assembling process [4]. Second weakness is the human workers whose safety has to be secured. In future, employing human workers in working with robots is in small production processes. In spite of recent assembling style, human is more flexible. Roots not only have to recognize the working robots and working safety states, but also have to work with human workers and other robots effectively [8]. The term "automatic assembling"refers to applying mechanical and automatic instruments for doing different assembling activities in assemble lines or cells. There have been large advances in assembling automation technology in recent years. Most of these advances were achieved due to robotic science growth [1]. Industrial robots are sometimes used as automatic assembling systems and majority of automatic assembling systems are designed for a fixed sequence of the assembling on a particular product [9].

3. Sensors in robotic assembling

Sensors are parts consisted of electrical or optimal sensing layers playing their roles along with other electronic elements. These elements' task is to receive information from robots location and environmental conditions such as light, temperature and targets in environment [2]. Sensors are often used for contacting, tensioning, proximity, visual and audialinformation perception. Their performance is in such a manner that they produce a negligible voltage levels in response to the factor changes they are sensitive to. It is possible to interpret the received information and make them used for future decision makings by processing the electrical signals mentioned [10]. Based on the significant complexity with assembling operation, the industrial robots are used in this regard. The uncertainty in positioning and parts direction as well as errors during assembling in industrial robots can be challenging. Recently, majority of applied plans including welding, spraying the body of cars, a part of casting process and injecting molding machineries, unloading and discharge etc. are conducted by robots [11]. Robot needs information acquirement in order to find more accuracy and repeatability. An industrial robot is used when there are more requirements for the typical functions and software and sometimes more information. For example, consider a controlling touching robot with fragile and flexible wrist. This robot is designed for touching which is similar to human hand [8]. Sensor used in measuring or detecting the environmental information is among the most crucial instruments in assembling operation. For working with a smart robot, there is sensory information needed such that one can change the information via programs. In addition to sensors, smart robots need sensory data organizing capability to make the considered task done [12].

4. Methodology

In electronic production systems the robotic arm design can be of significant importance for performing the assembling tasks as well as successful inter-robots coordinated assembling. Based on limitation on robotic arms traditional architecture, for example location and rotation

during the process, they cannot be recognized effectively. In this research, the robotic smart arm is designed and built for this purpose. The joint pairing using robot is investigated in this case. Different locations may be considered during the assemblage [5]. Since the goal of assembling is to design the fingers, in this research the hypotheses are made for this purpose.

In some electrical particular sections such as joint assemble, complementary joints, it is easy for parallel fingers to lift up a joint without dropping it. In electronic production, it is not highly required to part assemble friction. The joints are made of low-weight plastic materials such that the normal force is exerted from the finger.

In this article, in order to simulate the mechanism we used V-REP. here it is necessary to note that the main goal of this action in line with design a system with sensory feedback capabilities is not only overcoming the diversity based on different parameters such as robot working temperature and internal performance, but also for overcoming the uncertainty in positioning and direction of the parts from robot toward the decision making operation. For this end, the nail in hole parts pairing for the operation is selected. In order to facilitate the assemble operation, there is mild slope exerted on the nail.

5. Mechanism simulation

At first, the required parts are introduced to the software such as type of sensor, type of gripper as well as robot. Therefore here we used the LASER sensors because they provide more accurate measure

of the environment and are resistant against environmental factors. In addition, in most of the robotic sensors due to lack of coordination of robot motion with reading sensors, there are often challenges. Then, based on the robot motion we used the high resolution LASER sensors with high accuracy so prevent from errors occurrence. In LASER sensors like ultrasonic ones there is an optical package sent to the target and the round trip time is calculated. This requires accurately measuring time to the pulse/second accuracy. In this model, the difference between phase of the sending and returning optics are measured. The practical implementation of this model is easier. Our system acts in such a manner that we assume there is a square palate with a hole on it.

Under the gripper attached to the robot there are 3 plates embedded in order to parallelize the plate axis with the pallet such that there is a sensor on each plate and it is commanded. After reading, pallet parallelizes the axis and iterates it until the output values indicated from the plate axis are similar to the pallet's axis. After the sum of axis is equal to that of pallet, the "local frame of reference" command is given to the robot.

3-D coordinate and 6 degrees of freedom are extracted by the position broadcaster. Now, based on the coordinate of nail (or a cylindrical part displacing the gripper) as well as based on the hole centric coordinate, the robot is commanded. For example, the nail is put in 2 cm downward in the hole. As a result, it is observed that robot repeat it without any error and the first time it is dome the nail would be in the hole.
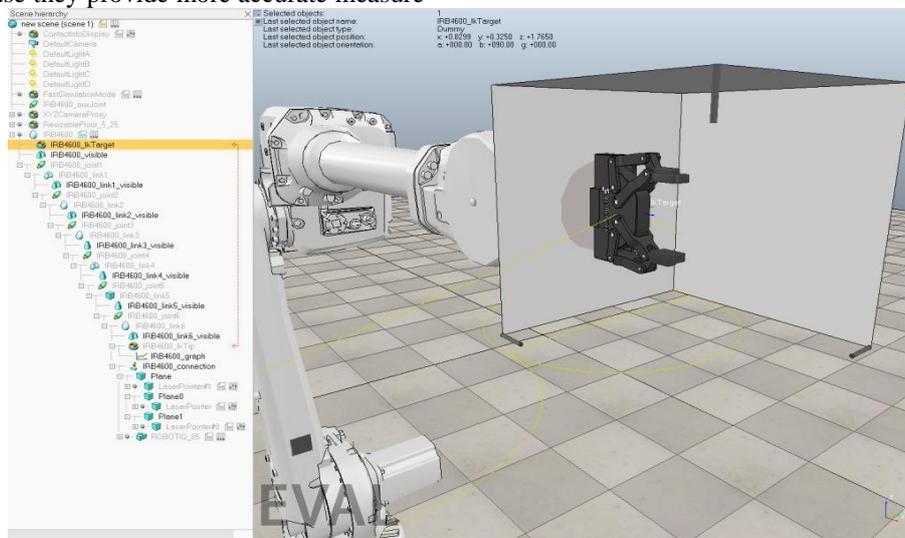
Fig. 1.   A view of the sensors and gripper places on the tip of instrument
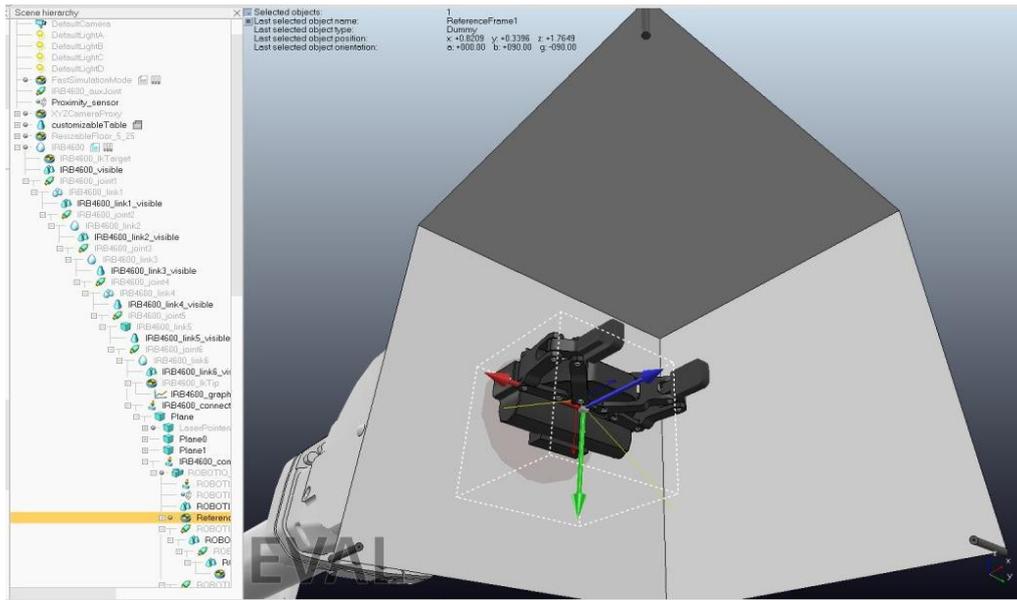
Fig. 2.   Schematic of the reference frame location

Fig. 3. Creating the reference frame location
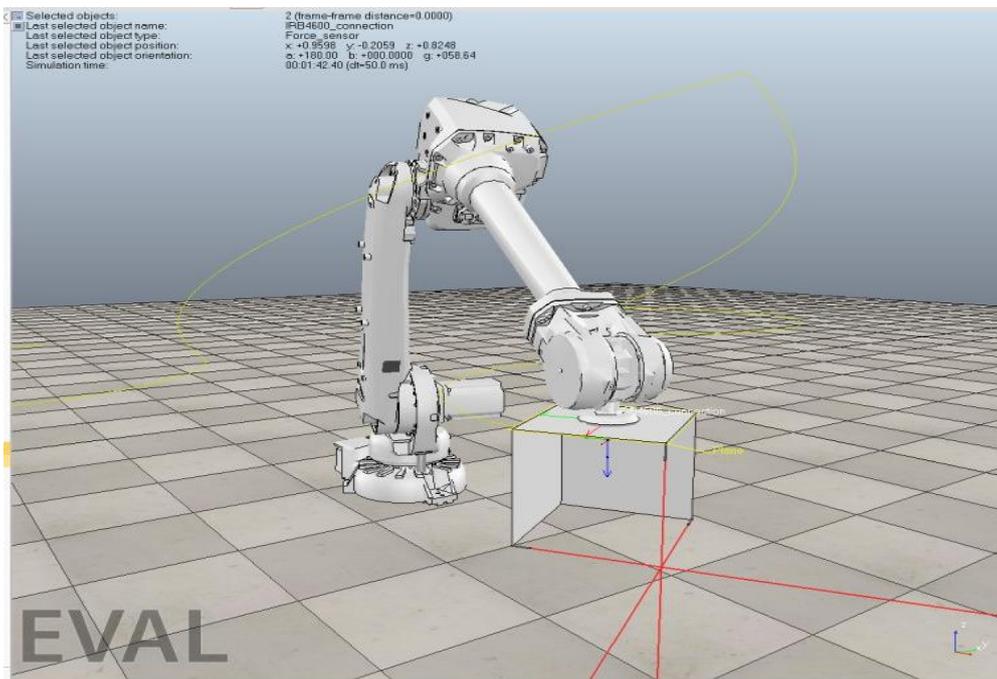
Fig. 4. Robot arm system turning on and location of sensors and the intersection of the sensor light

The main goal of this project is eliminating the error during the assembling so that we can assemble the parts without any error. When we limit the working space of robot, it is possible to receive more desirable output of robot. In this project, the definition of local frame of reference enabled us to overcome errors when nail is put into the hole. Here, the gripper selected is a typical one using which one can more easily move the parts for assembling.

6. Conclusion

Robot is a smart machine with ability to take the defined action under the condition it is put and it is capable of decision making in different situations. RCC is an optimal model used in this research. Based on the temperature and other factors increase for example of clearance in joints and coupling in different subsets of the robot and the effects of the systems errors, the measurement and control robot is a necessary instrument. Using presumptions defined in robot control systems and their algorithm as well as using sensors, one can reduce the above mentioned errors to some extent. It is necessary to note that parts transport system errors such as self-guided carts and conveyors are effective on assemble robotic process. Therefore, using local frame of reference which is taken into account in robot control systems like CNC machines reduces the working envelope and as a result increases the robot working accuracy. Making use of the robot system reference coordinate transfer to the local frame of reference coordinate, one not only can overcome the related errors to the robot but also that of part transport pallets. It is necessary to note that this issue causes displacement of the robot instruments, but only changes the machine location. The robot system works in such a manner that can make some local coordinates for user.

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